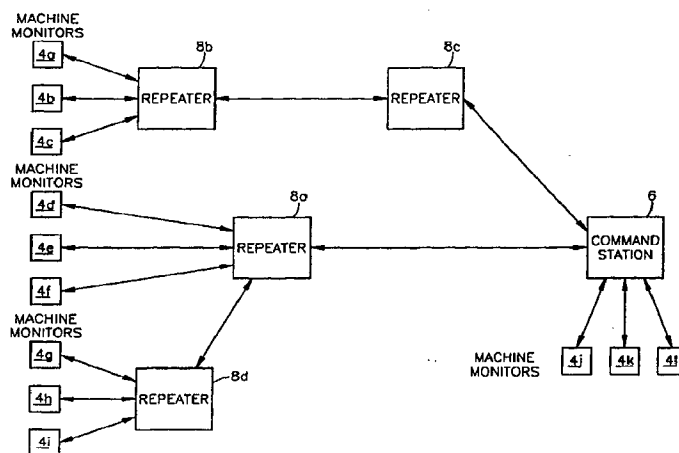




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(54) Title: VIBRATION MONITOR AND TRANSMISSION SYSTEM



(57) Abstract

An apparatus is disclosed consisting of one or more machine monitors (4a-l) which attach to one or more machines to sense a physical characteristic of the machine, such as vibration or temperature, and produce wireless transmissions corresponding to the sensed characteristic, and a command station (6) which receives the transmissions from the machine monitors (4a-l) and processes the information to give an indication of the condition of the machine. The machine monitor incorporates a wireless transmitter (446) to transmit the sensor data, and the command station (6) incorporates a wireless receiver (618) to receive the sensor data. In the preferred embodiment of the invention, the machine monitors (4a-l) are not continuously on, but turn on only at preprogrammed times according to turn-on commands generated by a timer circuit (424) within each monitor. Each machine monitor includes a microcomputer (418) to analyze the sensor data and a memory (422) to store the analyzed sensor data. Repeaters (8a-d) to facilitate communication between the command station and machine monitors are necessary.

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AMENDED CLAIMS

[received by the International Bureau on 17 March 1998 (17.03.98);
original claims 1, 5, 6, 23-25, 29 and 33-39 amended; new claims 40-42 added;
remaining claims unchanged (10 pages)]

1. A wireless monitoring system for monitoring a plurality of machines, the system comprising:

a plurality of machine monitors mounted on a plurality of machine measuring points, each machine monitor including:

5 at least one sensor for sensing a characteristic of the machine at the machine measuring point and generating at least one sensor signal corresponding to the machine characteristic that was sensed;

a data processor for receiving and analyzing the sensor signals and producing analyzed sensor signals; and

10 transmitter means for producing wireless transmission signals corresponding to the analyzed sensor signals; and

a command station including receiver means for receiving said transmission signals and storing data corresponding to said transmission signals and the sensed characteristics of the machines, whereby characteristics of the plurality of machines at the plurality of measuring points
15 are sensed and stored at said command station.

2. The system of Claim 1 wherein at least one of said machine monitors further comprises a microcomputer for receiving and analyzing the sensor signals, producing frequency domain data corresponding to the sensor signals, comparing the frequency domain data to predetermined criteria and determining an alarm condition based on the comparing of
5 the frequency domain data to the predetermined criteria.

3. The system of Claim 2 wherein said microcomputer performs a Fourier transform on the sensor signals to produce the frequency domain data in the form of a frequency spectrum.

4. The system of Claim 1 wherein at least one of said machine monitors further comprises a microcomputer for receiving and analyzing the sensor signals, producing time

5 wave form data corresponding to the sensor signals, comparing the time wave form data to predetermined criteria and determining an alarm condition based on the comparing of the time wave form data to the predetermined criteria.

5. The system of Claim 1 wherein at least one of said machine monitors further comprises a memory for storing data corresponding to the analyzed sensor signals.

6. The system of Claim 1 wherein at least one of said machine monitors further comprises a memory for storing data corresponding to the analyzed sensor signals, wherein the transmitter means of the at least one of said machine monitors produces wireless transmission signals corresponding to the stored data signals.

7. The system of Claim 1 wherein at least one of said machine monitors further comprises a timer for selectively energizing and de-energizing the machine monitor sensor, data processor, and transmitter means.

5 8. The system of Claim 1 wherein at least one of said machine monitors further comprises a wireless receiver means and said command station further comprises a wireless transmitter means for transmitting commands, said machine monitor receiving the commands through said wireless receiver means of said machine monitor and being responsive to said commands to control the operation of said machine monitor.

9. The system of Claim 1 further comprising a wireless repeater for receiving the wireless transmission signals from said machine monitor and re-transmitting the wireless transmission signals for receipt by said command station.

10. The system of Claim 1 wherein:
at least one of said machine monitors further comprises an analog-to-digital converter;
at least one of said data processors is a digital data processor for producing digital data corresponding to the sensor signals; and

5 at least one of said transmitter means produces wireless transmission signals corresponding to the digital data signals.

11. The system of Claim 1 wherein:

at least one of said machine monitors further comprises an analog-to-digital converter;

at least one of said data processors is a digital data processor for producing digital data corresponding to the sensor signals; and

5 at least one of said transmitter means produces wireless transmission signals corresponding to the digital data signals; and

said command station further comprises receiver means for receiving the wireless digital transmission signals.

12. The system of Claim 1 wherein:

at least one of said machine monitors further comprises an analog-to-digital converter;

at least one of said data processors is a digital data processor for producing digital data corresponding to the sensor signals;

5 at least one of said transmitters means produces wireless transmission signals corresponding to the digital data signals;

said command station further comprises receiver means for receiving the digital transmission signal and transmitter means for transmitting wireless command signals;

10 said at least one machine monitor further comprises receiver means for receiving said command signals; and

said digital data processor being responsive to said command signals to control the operation of the machine monitor.

13. The system of Claim 12 further comprising each of said transmitter means and receiver means transmitting and receiving a digital signal with an error checking protocol.

14. The system of Claim 1 further comprising said transmitter means and receiver means transmitting and receiving a digital signal, respectively, with an error checking protocol.

15. The system of Claim 1 wherein said transmitter means further comprise radio frequency transmitter means and said receiver means further comprise radio frequency receiver means.

16. The system of Claim 8 wherein said transmitter means further comprise radio frequency transmitter means and said receiver means further comprise radio frequency receiver means.

17. The system of Claim 1 wherein said transmitter means further comprise spread spectrum transmitter means and said receiver means further comprise spread spectrum receiver means, each using a spread spectrum communication protocol to avoid interference from other radio frequency emitters.

18. The system of Claim 8 wherein said transmitter means further comprise spread spectrum transmitter means and said receiver means further comprise spread spectrum receiver means, each using a spread spectrum communication protocol to avoid interference from other radio frequency emitters.

19. The system of Claim 1 wherein said transmitter means further comprise light wave transmitter means and said receiver means further comprise light wave receiver means.

20. The system of Claim 8 wherein said transmitter means further comprise light wave transmitter means and said receiver means further comprise light wave receiver means.

21. The system of Claim 1 further comprising;
an identification system incorporated into each machine monitor for storing and generating a unique identification code for each machine monitor, said identification code being transmitted by said transmitter means as part of said wireless transmission signals; and
said command station being responsive to the identification code to identify positively which machine monitor transmitted a particular received wireless transmission signal.

22. The system of Claim 1 further comprising a timer system for powering on said sensor, data processor, and transmitter means at the selected times, and powering off said sensor, data processor, and transmitter means at other times to reduce power consumption by said sensor, data processor, and transmitter means.

23. The system of Claim 9 further comprising a timer system for producing start-up signals at selected times for causing said sensor, analog to digital converter, data processor, transmitter means and receiver means of said at least one machine monitor to power on at the selected times for transmitting and receiving signals at the selected times and power off at other times to reduce power consumption.

24. The system of Claim 1 further comprising:

a clock in at least one machine monitor for producing clock signals corresponding to time;

said data processor in at least one machine monitor being responsive to said clock signals for producing start-up signals at selected times in response in part to said clock signals, and for producing shut-down signals,

said sensor and transmitter means of said at least one machine monitor being responsive to said start-up signals to power on, sense the machine characteristic, generate the sensor signals corresponding to the machine characteristic, and transmit the sensor signals at the selected times, and being responsive to said shut-down signals to power off at other times to reduce power consumption by said sensor and transmitter means.

25. The system of Claim 1 further comprising:

a clock in at least one machine monitor for producing clock signals corresponding to time;

said data processor in said at least one machine monitor being responsive to said clock signals for producing start-up signals at selected times in response in part to said clock signals, for producing shut-down signals at other times, and for producing data corresponding to the analyzed sensor signals;

memory in said at least one machine monitor controlled by said data processor for storing data corresponding to the analyzed sensor signals;

10 said at least one sensor of said at least one machine monitor being responsive to said start-up signals to power on at the selected times and sense a machine characteristic and produce sensor signals corresponding to the sensed machine characteristic, and being responsive to said shut-down signals to power off at the other times to reduce power consumption by said sensor;

15 said transmitter means of said at least one machine monitor being responsive to said start-up signals to power on at the selected times and produce wireless transmission signals corresponding to the stored data signals, and being responsive to said shut-down signals to power off at the other times to reduce power consumption by said transmitter means.

26. The system of Claim 1 wherein each of said machine monitors is mounted within a housing sufficiently small, having dimensions of about two inches by two inches by three inches, to be mounted unobtrusively on machines.

27. The system of Claim 1 wherein each of said machine monitors further comprises:
a relatively small housing for being mounted on a machine;
attachment means for attaching the housing to said machine;
a battery of sufficiently small size to be disposed within said housing, and having
5 sufficient capacity to power said sensor, data processor, and transmitter means for a time period of about a year; and
mounting means for mounting each element of the machine monitor within said housing.

28. The system of Claim 1 wherein said data processor of at least one of said machine monitors receives and analyzes the sensor signals, produces analyzed signals, compares the analyzed signals to predetermined criteria, and determines an alarm condition based on the comparing of the analyzed signals to the predetermined criteria.

29. The system of Claim 28 wherein said at least one of said machine monitors further comprises:

said data processor for producing a start-up signal, alarm data, and an alarm transmit signal when an alarm condition is determined to exist; and

5 said transmitter means for said at least one machine monitor being responsive to said start-up signal to power on, and being responsive to said alarm transmit signal to transmit a wireless transmission signal corresponding to said alarm data.

30. The system of Claim 29 wherein said transmitter means for said at least one machine monitor is responsive to said alarm transmit signal to produce a transmission signal that is different from other wireless transmission signals produced by the transmitter means of other machine monitors so that interference is avoided.

31. The system of Claim 29 wherein said transmitter means for said at least one machine monitor is responsive to said alarm transmit signal to produce a transmission signal that has a different frequency range from the other wireless transmission signals produced by the transmitter means of other machine monitors so that interference is avoided.

32. The system of Claim 29 wherein said transmitter means for said at least one monitor is responsive to said alarm transmit signal to produce a transmission signal at different times as compared to the other wireless transmission signals produced by the transmitter means of other machine monitors so that interference is avoided.

33. A monitoring system for monitoring a machine, comprising:
a monitor including the following elements:

at least one sensor for sensing a physical characteristic of said machine at a machine measuring point and generating at least one analog sensor signal corresponding to the physical
5 characteristic that was sensed;

an analog to digital converter for producing digital sensor signals corresponding to said analog sensor signals;

a monitor computer for receiving the digital sensor signals, analyzing the digital sensor signals and producing analyzed sensor signals, storing and producing data corresponding to the analyzed sensor signals, and producing messages;

monitor wireless transmitter means responsive to the messages for producing monitor wireless transmission signals corresponding to the analyzed sensor signals;

monitor receiver means for receiving wireless signals and producing received signals for being transferred to said monitor computer;

a power supply; and

a housing for mounting on the machine and housing at least some of the monitor elements; and

a command station including the following elements:

command station receiver means for receiving and transferring said monitor wireless transmission signals and transferring data corresponding to the received signals to a command station computer;

a command station computer for receiving and storing data corresponding to the received signals, producing data, and producing commands; and

command station transmitter means for transmitting command wireless transmission signals corresponding to data and commands received from said command station computer.

34. The system of Claim 33 further comprising:

said command station for producing and transmitting scheduling commands corresponding to the time of day that the monitor transmitter means should start-up and transmit data;

said monitor receiver means receiving and transferring said scheduling commands to said monitor computer;

said monitor computer being responsive to said scheduling commands to issue start-up signals at selected times corresponding to the scheduling commands; and

said monitor transmitter means being responsive to the start-up signals to power on and, under control of said monitor computer, produce monitor wireless transmission signals.

35. The system of Claim 34 further comprising said monitor receiver means being responsive to the start-up signals to power on and, under control of said monitor computer, receive wireless signals and produce received data for transfer to said monitor computer.

36. The system of claim 35 further comprising:

said monitor computer for transferring data to said monitor transmitter means for being transmitted, for monitoring the transmission of said data, and for producing shut-down commands after the successful transmission of said data; and

5 said monitor transmitter means being operable to transmit monitor wireless signals corresponding to said data and being responsive to the shut-down signal to power off to conserve power.

37. The system of Claim 36 further comprising said monitor receiver means being responsive to said shut-down signal to power off to conserve power.

38. The system of Claim 33 further comprising:

at least two monitors of Claim 33, each of said monitors further comprising:

said monitor computer having a stored identification code identifying the monitor and distinguishing it from others, and producing identification signals for transfer to
5 said monitor transmitter means; and

said monitor transmitter means for transmitting identification wireless signals corresponding to said identification code;

said command station receiver means for receiving said identification wireless signals and transferring the identification code to said command station computer;

10 said command station computer being operable to identify a monitor based on said identification code.

39. The system of Claim 38 further comprising:

said command station computer being operable to generate identification codes as part of a data packet and producing data packet signals for transfer to said command station transmitter means;

5 said command station transmitter means being operable to transmit data packet wireless signals corresponding to the data packet;

said monitor receiver means being operable to receive the data packet wireless signals and transfer data packets to said monitor computers;

10 each of said monitor computers, having a unique internal identification code, for comparing and determining whether the data packet identification code is the same as the internal identification code, responding in a first manner when said internal code and packet code are the same, and responding in a second manner when said internal code and packet code are not the same.

40. The system of Claim 1 wherein said at least one sensor comprises a plurality of sensors producing a plurality of sensor signals corresponding to a plurality of machine characteristics.

41. The system of Claim 40 wherein one of said sensors is a vibration sensor.

42. The system of Claim 40 wherein one of said sensors is a temperature sensor.

STATEMENT UNDER ARTICLE 19

This statement specifically refers to the Amendment of Claims under Article 19 filed March 16, 1998 for Application Number PCT/US97/14584 entitled VIBRATION MONITOR AND TRANSMISSION SYSTEM. Applicants submit this Amendment of Claims to clarify and further define patentable aspects of the invention. As amended, the claims are in the same form as the claims of the U.S. Patent and Trademark Office for the subject invention.

This Amendment of Claims is expected to have no impact on the description or drawings.